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Slow Very Highly Charged Ions: A New Tool for Surface Analysis

T. Schenkel[1,2], A. V. Hamza, A V. Barnes[3], K. Bethge[2], and D. H. Schneider[1]

[1]*Physics and Space Technology Directorate, Lawrence Livermore National Laboratory, Livermore, CA 94550*

[2]*Institut für Kernphysik der J. W. Goethe Universität Frankfurt, D-60486 Frankfurt*

[3]*Department of Physics, Vanderbilt University, Nashville, TN*

Secondary Electron Microscopy and Secondary Ion Mass Spectrometry are among the most widely used surface analysis techniques. In standard SIMS, primary ion beams consist of singly charged, keV ions. Secondary ion production results from momentum transfer along a collision cascade produced by incident ions in the target; a process in which useful yield generation is accompanied by extensive sample damage. Typical sputter yields are ~ 3-10 target atoms per incident ions, while secondary ion yields per incident ion are often smaller than 10^{-2}. Our novel approach to secondary particle generation in ion solid interactions is the use of slow ($v<<v_{Bohr}$), very highly charged primary ions, like Xe^{44+} or Au^{69+}. The interaction of highly charged ions with surfaces is characterized by a dominance of electronic over collisional effects. A single Au^{69+} ion invests a total potential energy of ~ 160 keV into a nanometer sized near surface volume when it neutralizes at it's impact on a surface. The energy density of such a neutralization process is much higher than the corresponding near surface nuclear energy loss of a singly charged ion at the same kinetic energy ($S_n \leq 5$ keV/nm). Consequently, secondary electron- and ion production rates are increased by two orders of magnitude in highly charged ion based secondary electron microscopy and SIMS. Fig.1 shows negative secondary ion spectra from a graphite target (HOPG). Incident ions were Xe^{1+} and Th^{70+} at similar kinetic energies (2.3 and 3 keV/amu), the detection efficiency of ~ 10% is not included. Substantial useful yield increases in TOF-SIMS could result in drastically improved sensitivity limits for the detection of surface impurities beyond the current limits of ~10^9 - 10^{11} at/cm^2.

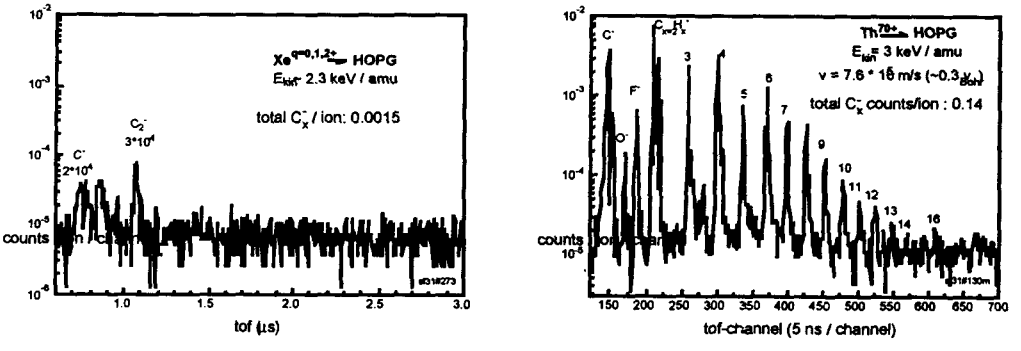

Fig. 1: Comparison of negative secondary ion production from a graphite target at impact of Th^{70+} and Xe^{1+} at kinetic energies of 3 and 2.3 keV/ amu.

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